Evidence against a chondritic Earth

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The 142Nd/144Nd ratio of the Earth is greater than the solar ratio as inferred from chondritic meteorites, which challenges a fundamental assumption of modern geochemistry—that the composition of the silicate Earth is 'chondritic', meaning that it has refractory element ratios identical to those found in chondrites. The popular explanation for this and other paradoxes of mantle geochemistry, is an incompatible element hidden layer deep in the mantle, which must including 40% of the mantle's heat producing elements in order to explain the Nd anomaly. This requires the mantle plumes to carry at least 40% of the mantle's heat budget, which is inconsistent with constraints on the plume heat flux that put the this figure at less than 30%. Furthermore the sudden drop in the temperature of mantle plumes that occurred a ~2.5 Ga is interpreted to indicate that that D", which is commonly interpreted to be the hidden layer, did not form until that time. If the hidden layer (D") formed after the first 10 Myr of the Earth's evolution it cannot be responsible for the Earth's 142Nd/144Nd anomaly. Either the matter from which the Earth formed was not chondritic, or the Earth has lost incompatible elements rich matter by collisional erosion in the later stages of planet formation.

Mining, microbes, and models: Integrating microbal Fe(II) oxidation, hydrolysis, precipitation, and biogeochemical modeling, with application to acid mine drainage at Iron Mountain

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Acid mine drainage (AMD) is a major environmental concern because of high concentrations of acidity (low pH), sulfate, iron, and other elements. One important process affecting AMD chemistry is microbial Fe(II) oxidation. As Fe(II) oxidizes, a variety of Fe(III)-bearing minerals can precipitate, affecting the immobilization of elements such as Cu and Zn, as well as redox cycling of trace elements such as As and Sb. Precipitation can also cause costly management problems when it interferes with treatment efforts. An example of this problem occurred at the Iron Mountain Mine (CA, USA) where a pipeline carrying AMD to a treatment plant has developed scaling because of Fe(II) oxidation and Fe(III) precipitation inside the pipe. The scale accumulation has clogged flow and caused spillage of AMD, requiring expensive periodic cleaning of the pipeline.

Laboratory Fe(II) oxidation experiments were conducted using synthetic AMD with Fe(II)-oxidizing bacteria, and compared to experiments using natural AMD from Iron Mountain. Changes in pH, Fe(II), Fe(III), and trace elements were measured over time. The precipitates formed were characterized, and the micobial community was identified (16S rDNA). Water samples and scale collected from four locations along the pipeline also were characterized.

We developed a geochemical model to evaluate our understanding of coupled biotic and abiotic processes in AMD. Key processes included in the model are equilibrium reactions for all measured constituents, microbial Fe(II) oxidation kinetics, Fe(III) hydrolysis and polymerization, mineralogy, solubility, Fe(III) precipitation kinetics, and As(III) oxidation. This work highlights the utility of geochemical models as a means of improving quantitative descriptions of fundamental biogeochemical processes in AMD. Based on the geochemical model and laboratory experiments, we developed a potential mitigation strategy for the scaling problem that avoids costly pipeline maintenance.

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